CALIBRATION OF A WEATHER BUREAU TIPPING-BUCKET RAINGAGE

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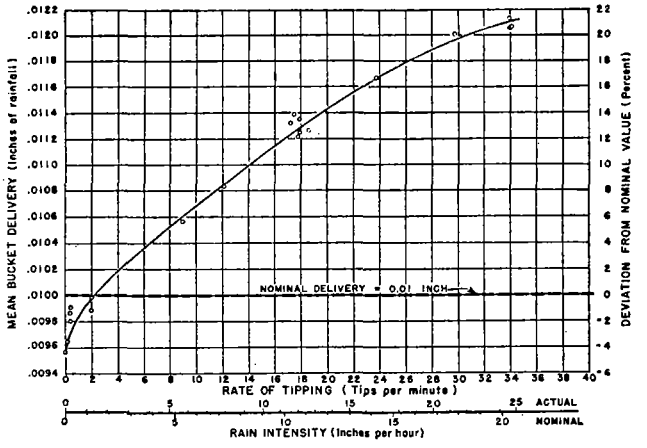
In the course of instrumentation research conducted by the Soil Conservation Service, a standard United States Weather Bureau tipping-bucket raingage was calibrated. Since all of the longer records of rainfall intensity in the United States were obtained with this instrument, the results of this calibration are here presented for the benefit of those called upon to interpret Weather Bureau records of rainfall intensity.

The gage calibrated was furnished by the United States Weather Bureau and bore Bureau Serial No. 347. The instrument was manufactured by Julien P. Friez & Sons in May 1918.

The calibration was made by the Soil Conservation Service. Facilities for the work were provided by the National Bureau of Standards, Washington, D. C.

In calibrating the gage, a steady flow of water was discharged into the funnel. The rate of tipping was determined by counting the number of tips during a measured time interval. The rate of flow was obtained



by weighing the water discharged during the measured time intervals.

The calibration derived from the tests is shown on the accompanying diagram. It is evident from this graph that when the bucket is tipping at a rate of about two tips per minute, it delivers 0.01 inch of rainfall at each tip. For faster rates of tipping the delivery of the bucket is greater than 0.01 inch, and for slower rates is less than this amount. In other words, the records of intensities higher than 1.2 inches per hour are too low and the records of lesser intensities exceed the actual rates. This tendency was pointed out by B. C. Kadel, "Measurement of Precipitation," W. B. *Circular* E, 4th ed., 1936, pp. 10–11.

The percentage deviation of the "nominal" from the "actual" intensity of rainfall is indicated by the scale on the right hand side of the accompanying diagram. The nominal rate is equal to .01, the nominal bucket delivery in inches of rainfall, times the number of tips which would occur in one hour at the given rate of tipping. To obtain the actual intensity, multiply the nominal rate by the factor, 100 times actual bucket delivery, the actual delivery being taken from the left hand scale of the diagram. The portion of the curve beyond 25 tips per minute has no practical significance, since natural rainfall almost never occurs at even this rate; the purpose in carrying the graph out so far was to show the group data points at about 34 tips per minute, which of course help in locating the curve at lower rates.

The Soil Conservation Service has investigated several tipping-bucket devices of different sizes and shapes. As a result of this work, it has been concluded that if all tipping-bucket instruments of a given design are adjusted to deliver the same quantity of water at a given rate of tipping, the delivery of all of the gages will be substantially the same at all other rates of tipping.

The principal condition necessary for the maintenance of a given calibration is an unchanging moment of force of the empty bucket about the fulcrum. This moment will be changed if any of the following alterations are made:

1. A change in the angle through which the bucket tips.
2. A shift in the center of gravity relative to the fulcrum.
3. A change in the weight of the bucket.

To reduce the labor required to convert reported rates to actual intensities, the accompanying table was prepared. While it may be considered exact for only the particular gage calibrated, it is obvious from the foregoing that it can be used with considerable confidence for all gages of the same pattern, provided all of these gages have been adjusted to deliver 0.01 inch of rain when the rate of tipping is about two tips per minute. It is the standard practice of the manufacturer to adjust all instruments to this delivery before they leave the factory. If they have not been readjusted or altered in the field the conversion table should, therefore, be applicable.

The foregoing applies only to determinations of rainfall rates, and has no bearing upon the measurement of total amounts. This has customarily been done independently of the tipping-bucket mechanism with measuring tube and stick.

RAIN INTENSITY

(W. B. Tipping-Bucket Raingage No. 347)

[Inches per hour]

Tips per minute	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	0.00	0.06	0.12	0.17	0.23	0.29	0.35	0.41	0.47	0.53
1	.59	.65	.71	.77	.83	.89	.95	1.01	1.07	1.14
2	1.20	1.26	1.32	1.38	1.44	1.51	1.57	1.63	1.69	1.76
3	1.82	1.88	1.94	2.01	2.07	2.13	2.19	2.26	2.32	2.38
4	2.44	2.51	2.57	2.64	2.70	2.77	2.83	2.89	2.95	3.02
5	3.08	3.15	3.21	3.28	3.34	3.41	3.47	3.54	3.60	3.67
6	3.73	3.80	3.86	3.93	3.99	4.06	4.12	4.19	4.25	4.32
7	4.38	4.45	4.52	4.59	4.65	4.72	4.78	4.85	4.91	4.98
8	5.05	5.12	5.19	5.26	5.32	5.39	5.45	5.52	5.59	5.66
9	5.72	5.79	5.86	5.93	6.00	6.07	6.14	6.21	6.27	6.34
10	6.41	6.48	6.54	6.61	6.68	6.75	6.82	6.89	6.96	7.03
11	7.10	7.17	7.24	7.31	7.38	7.45	7.52	7.59	7.66	7.73
12	7.80	7.87	7.95	8.02	8.09	8.16	8.23	8.30	8.37	8.45
13	8.52	8.59	8.66	8.73	8.80	8.87	8.94	9.01	9.09	9.16
14	9.24	9.31	9.38	9.45	9.53	9.60	9.67	9.74	9.82	9.89
15	9.96	10.04	10.11	10.19	10.26	10.34	10.41	10.48	10.55	10.62
16	10.69	10.77	10.85	10.92	11.00	11.07	11.15	11.22	11.29	11.37
17	11.44	11.52	11.59	11.67	11.75	11.83	11.89	11.96	12.04	12.12
18	12.19	12.27	12.34	12.42	12.50	12.57	12.64	12.72	12.80	12.88
19	12.95	13.03	13.11	13.19	13.26	13.34	13.41	13.49	13.57	13.65
20	13.72	13.80	13.88	13.96	14.03	14.11	14.18	14.26	14.33	14.41
21	14.48	14.56	14.64	14.72	14.79	14.87	14.94	15.02	15.10	15.18
22	15.26	15.34	15.41	15.49	15.56	15.64	15.73	15.81	15.88	15.95
23	16.04	16.12	16.19	16.27	16.34	16.42	16.50	16.58	16.65	16.73
24	16.80	16.88	16.96	17.04	17.13	17.20	17.28	17.36	17.44	17.52

Rating derived from tests made by the Soil Conservation Service at the Hydraulic Laboratory of the National Bureau of Standards.